ARTÍCULO ORIGINAL

VALUE OF ENTOMOLOGICAL COLLECTIONS IN THE STUDY OF BIODIVERSITY: EXAMPLES FROM THE COLLECTION OF HARD SCALES (HEMIPTERA: DIASPIDIDAE), WHITEFLIES (HEMIPTERA: ALEYRODIDAE) AND SWEAT BEES (HYMENOPTERA: HALICTIDAE) AT THE CALIFORNIA ACADEMY OF SCIENCES

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Abstract.

This paper demonstrates the value of entomological collections in the study of biodiversity citing examples from material that was deposited at the California Academy of Sciences in San Francisco that resulted into the description of new insect species. Specimens used from this collection include whiteflies (Hemiptera-Sternorryncha-Aleyrodidae), armored scales (Hemiptera-Sternorryncha-Coccoidea-Diaspididae) and sweat bees (Hymenoptera-Halictidae).

Key words: Apoidea, Coccoidea, Entomological collection, *Gadigaleyrodes*, Taxonomy.

Resumen.

En el presente artículo demostramos la importancia que posen las colecciones de entomología para el estudio de la diversidad, en particular, se proveen ejemplos de material que estaba depositado como misceláneo en las colecciones de la Academia de Ciencias de California en San Francisco. Las partes de la colección utilizadas para los ejemplos incluyen las moscas blancas (Aleyrodidae), escamas duras (Diaspididae) y abejas del sudor (Halictidae).

Palabras clave: Apoidea, Coccoidea, Colecciones entomológicas, Gadigaley-rodes, taxonomía.

Introduction:

Work and new species found in miscellaneous material at the California Academy of Sciences

The California Academy of Sciences collection (CAS) has one of the largest entomological collection in the United States; in fact, their holdings were estimated to more than 15 million specimens (Norman Penny, pers.comm), which represents twice the number reported in 2004 by Suarez and Tsutsui. The CAS provides important resources to the study of the diversity of insects worldwide. Museums provide important functions such as receiving, curating, preserving, and identifying specimens while maintaining associated data (such as field notes, geographical coordinates, host records, and valuable biological information) for future research (Ross 1950, Winston 2007). In addition, CAS provides other services such as research, education, and public outreach.

In general the biological collections at CAS maintain and keep biological data up to date and that document past and present-day patterns of biological distribution and diversity in our planet and are primary source for taxonomic work (such as taxonomic revisions and species description and name holding) as well as other biological disciplines.

While working in the curation of some sections of the CAS the authors discovered several undescribed species of armored scales (Hemiptera-Sternorryncha-Coccoidea- Diaspididae), whiteflies (Hemiptera-Sternorryncha-Aleyrodidae) and sweat bees (Hymenoptera- Halictidae) some of which have been described and published as new to science in recent years. The armored scale *Protomorgania koebelei* Dooley and Evans (2012) (figure1) and the whitefly *Gadigaleyrodes froggatti* Dooley and Gillespie (2013) (figure 2) were recently described even though they were collected more than a hundred years ago, This contribution aims to highlight the importance of natural history collections, and in particular that of the CAS, as holders of uncounted new species awaiting for description.

Origins of material and the process of discovery

The specimens referred herein are deposited at the CAS (Norman Penny, Collection Manager) and which represent examples of the entomological fauna for every zoogeographical region of the world.

At the beginning of this work, miscellaneous armored scales and whiteflies were slide mounted from specimens with their associated hosts using the techniques presented by Dooley (2011) since the material for this two families were found only dried without slide mounted specimens, including material collected by Froggatt (Froggatt 1932) and Koebele more than a century ago.

Another source of armored scales for some of the remarkable species found (and slide mounted) came from fresh material collected during 2002 as part of the Madagascar Diversity Project directed by the California Academy of Sciences (CAS) by Brian Fisher (PI). These specimens were preserved in 95% alcohol and sent to the University of Massachusetts at Amherst for non-destructive DNA extraction and sequencing. Based on a combination of information from two nuclear loci (28S, EF1a), one mitochondrial locus (COI-II), and morphological data, two new species each of genus *Melissoaspis* and *Melanaspis* have been described and are being published (S. Schneider pers. comm.).

In the case of the bees, just to cite an example one of us (AHSP) discovered a new species of bee when sorting out undetermined Halictidae bees; *Habralictus insularis* Smith-Pardo, 2009 (figure 3) described and some interesting remarks about its biogeography were also published by Smith-Pardo (2005) among some remarkable things, this was the first species of the genus *Habralictus* published in more than 30 years, and represented the second known species in the same genus inhabiting an island.

Conclusions

Natural history collections, such as the one at CAS are important not only as holder of material for morphological or taxonomical studies, but also as a source of material for molecular studies that lead to the development of molecular diagnostic tools for stages of some groups of insects, that cannot be identified morphologically to species, such as adult whiteflies or immature armored scales.

We believe that by offering the examples above we emphasize even more the enormous importance of natural history collections and their care, continually curating and studying collections including digitization of data and imaging identified taxa, revising lists of established taxa with newly described genera and species, and better documentation of geographical distribution and host preferences of all species are a most of we want to keep a collection active and “alive”.

Acknowledgments

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Table 1. List of whiteflies and hard scales at the CAS: first genus (two species) corresponds to Aleyrodidae, all other genera are Diaspididae. Generic names in bold letters have more than one species.

Genus	Species	Author	Host	Origin
Melissoaspis	*fisheri*	Ben-Dov	undetermined	Madagascar
	reticulata	Ben-Dov	undetermined	Madagascar
Melanaspis	*madagascariensis*	(Mamet)	undetermined	Madagascar
Morganella	*formicaria*	Ben-Dov	undetermined	Madagascar
Gadigaleyrodes	*froggatti*	Dooley & Gillespie	"Syncarpia"	Australia
Acutaspis	*albopicta*	(Cockerell)	*Rosa* sp.	Mexico
Adiscoiorinia	*secreta*	Green	*Nephelium* sp.	Hong Kong
Andaspis	sp. (*A. crawii*?)	NA	*Quercus cuspidata*	Japan
Aonidia	sp.	NA	*Quercus salicifolia*	Hong Kong
Aonidiella	*aurantii*	(Maskell)	*Olea europaea*	Australia
	citrina	(Coquillet)	*Cydonia* sp.	Western Samoa
	orientalis	Newstead	*Erythrina variegata*	Hong Kong
Aulacaspis	*vitis*	(Green)	undetermined	Hong Kong
Aulacaspis	*vitis*	(Green)	*Eleagnus* sp.	Taiwan
Chortinaspis	*bilobis*	(Maskell)	grass	Hong Kong
Chrysomphalus	*aonidum*	Linnaeus	undetermined	Taiwan
	dictyospermi	(Morgan)	*Citrus* sp.	Taiwan
Diaspidiotus	*liquidenbaris?*		*Petrea* sp.	Mexico
	perniciosus	(Comstock)	*Pyrus achras*	Hong Kong
Duplaspidiotus	*claviger*	(Cockerell)	*Hakea* sp.	Australia?
Epidiaspis	*leperii*	((Signoret)	undetermined	California
Epidiaspis	*leperii*	(Signoret)	*Malus* sp.	California
Fiorinia	sp.	NA	*Juniperus* sp.	Taiwan
	sp.	NA	undetermined	undetermined
	sp.	NA	*Torreya nucifera*	Japan
Hemiberlesia	*lataniae*	(Signoret)	*Celtis occidentalis*	Mexico
	lataniae	(Signoret)	*Opuntia* sp.	Mexico
	lataniae	(Signoret)	undetermined	Mexico
	lataniae	(Signoret)	*Nicotiana* sp.	Mexico
	lataniae	(Signoret)	*Phoradendron* sp.	Mexico
	lataniae	(Signoret)	undetermined	Mexico
	lataniae	(Signoret)	"Copal"	Mexico
	lataniae	(Signoret)	undetermined	Fiji
	rapax	(Comstock)	*Cereus* sp.	Mexico

	rapax	(Comstock)	*Asclepias* sp.	Mexico
	rapax	(Comstock)	*Mimosa* sp.	Mexico
	rapax	(Comstock)	undetermined	Mexico
	rapax	(Comstock)	undetermined	undetermined
	rapax	(Comstock)	*Malus* sp.	California
	rapax	(Comstock)	*Hedera* sp.	California
	rapax	(Comstock)	*Arctostaphylos* sp.	California
Hemiberlesia	*rapax*	(Comstock)	undetermined	undetermined
Lepidosaphes	*beckii*	(Newman)	*Myrtus* sp.	California
	beckii	(Newman)	*Citrus sinensis*	Sri Lamka
	conchiformis	(Gmelin)	*Crataegus* sp.	Mexico
	mexicana	(Cockerell)	Nettle tree	Mexico
	newsteadi	(Sulc)	*Sciadopitys verticillata*	Japan
	sp.	NA	*Panicum* sp.	Hong Kong
	tubulorum	Ferris	*Melia* sp.	China
	ulmi	(Linnaeus)	*Myrtus* sp.	California
Lopholeucaspis	*japonica*	Cockerell	*Celtis occidentalis*	Hong Kong
Melanaspis	*obscura*	(Comstock)	*Acer* sp.	Mexico
	smilacris	(Cockerell)	undetermined	New York
	sp.	NA	*Quercus* sp.	Arizona
	sp.	NA	*Syringa* sp.	Mexico
Mycetaspis	*personata*	(Comstock)	*Prosopis* sp.	Mexico
Oceanaspidiotus	*spinosus*	(Comstock)	undetermined	Mexico
Odonaspis	*oshimaenis*	Kuwana	*Bambusa tessallata*	Japan
Opuntiaspis	*carinata*	(Cockerell)	*Citrus aurantiifolia*	Mexico
	philococcus	Cockerell	*Cereus* sp.	Mexico
Parlatoria	*theae*	Cockerell	*Thea* sp.	Japan
Pinnaspis	sp.	NA	*Eugenia* sp.	Japan
	theae	(Maskell)	*Tea* sp.	Taiwan
Poliaspis	sp.	NA	*Acacia* sp.	Australia
Protodiaspis	Sp.	NA	*Quercus* sp.	Mexico
	sp.	NA	undetermined	Mexico
Protomorgania	*koebelei*	Dooley and Evans	*Pittosporum* sp.	Australia
Pseudaonidia	*cingulata*	Froggatt	*Casuarina* sp.	Australia
Pseudaulacaspis	*cockerelli*	(Cooley)	*Eugenia* sp.	Hawaii
	cockerelli	(Cooley)	*Michaelia figo*	California
	cockerelli	(Cooley)	undetermined	Sri Lanka
	cockerelli	(Cooley)	*Artocarpus* sp.	Hong Kong
	cockerelli	(Cooley)	Palmaceae	Australia
	cockerelli	(Cooley)	undetermined	Sri Lanka

	cockerelli	(Cooley)	*Eucalyptus* sp.	
	cockerelli	(Cooley)	*Ptychosperma* sp.	Australia
	cockerelli	(Cooley)	Palmaceae	Australia
Selenaspidus	*articulata*	Say	*Citrus* sp.	Mexico
Thysanofiorinia	*nephelii*	Maskell	*Dimocarpus longan*	China
Unaspis	sp.	NA	undetermined	Mexico

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Figure 1. *Protomorgania koebelei* Dooley and Evans. 2012. Illustration by Dr. Greg Evans and image by John Dooley. Original condition of specimens in the collection (left), same specimens slide mounted and illustrated (right).

Figure 2. *Gadigaleyrodes froggatti* Dooley and Gillespie 2013. Image by John Dooley

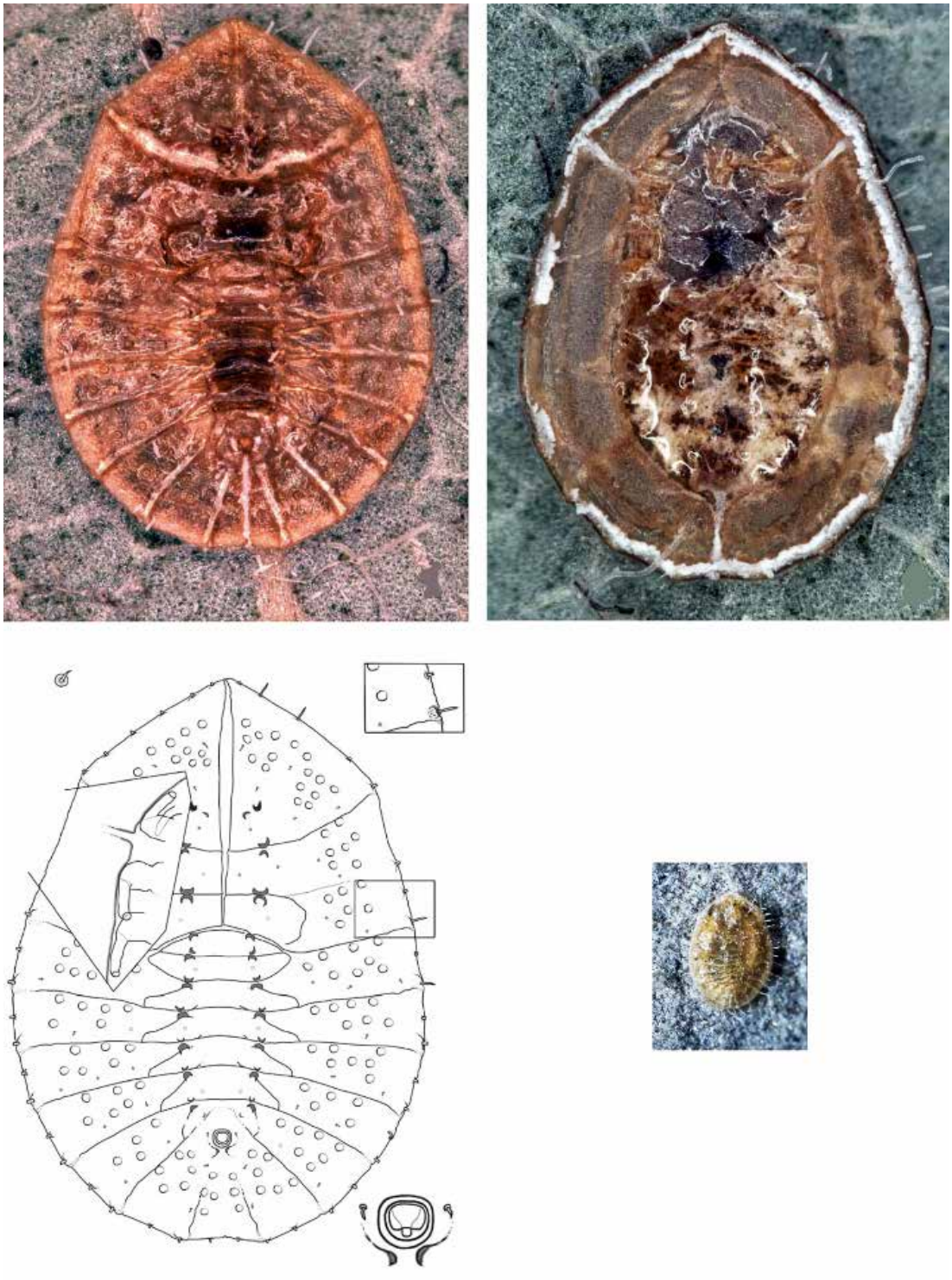

Figure 3. Male (left) and female (right) of *Habralictus insularis* Smith·Pardo, 2009.